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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : B21D 53/30, B23K 20/12, B60B 5/00 — A1

(11) International Publication Number: **WO 99/33594**

(43) International Publication Date: 8 July 1999 (08.07.99)

(21) International Application Number: PCT/US98/27853

(22) International Filing Date: 30 December 1998 (30.12.98)

(30) Priority Data:
60/070,023 30 December 1997 (30.12.97) US

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(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, GM, HR, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

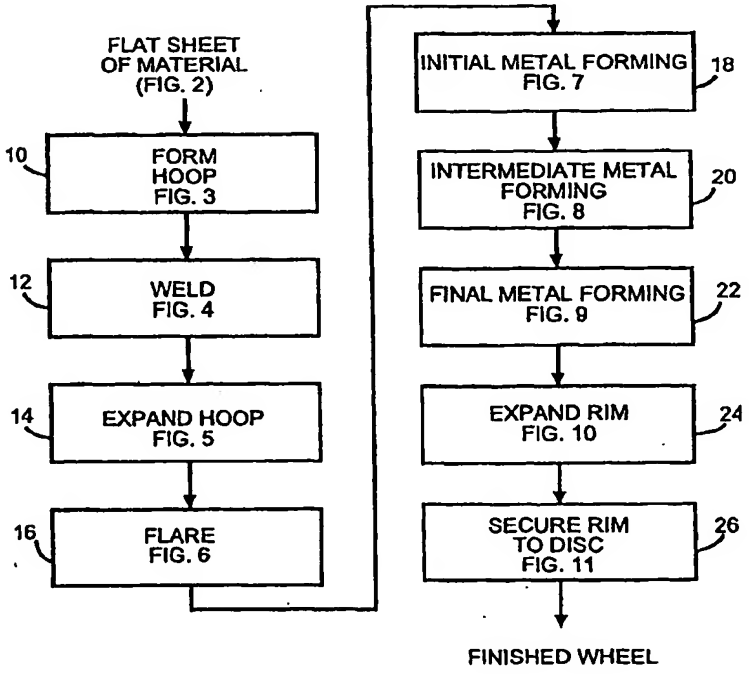
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: WHEEL RIM AND METHOD FOR PRODUCING SAME

(57) Abstract

An improved wheel rim and method for producing the same using a rim blank which has been formed into a hoop and joined together by a friction stir welding process is disclosed. The method for producing the wheel rim of the present invention includes the steps of: (a) providing a flat blank of material having a pair of opposed ends; (b) providing a chamfer in the opposed ends of the flat blank; (c) positioning the opposed ends of the blank adjacent one another to form a generally cylindrical hoop; (d) providing a pair of flats on the hoop in the region where the opposed ends meet; (e) joining the flattened opposed ends of the hoop together using a friction stir welding process; and (f) subjecting the hoop to one or more metal forming processes in order to produce a desire wheel rim.



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TITLE

WHEEL RIM AND METHOD FOR PRODUCING SAME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application Serial No. 60/070,023, filed December 30, 1997.

BACKGROUND OF THE INVENTION

This invention relates in general to vehicle wheels and in particular to an improved wheel rim and method for producing the same.

A typical sequence of steps which can be used to produce a wheel rim for a vehicle wheel is disclosed in U.S. Patent No. 4,185,370 to Evans. As shown in this patent, the method includes the steps of: (a) providing a flat sheet of suitable material, such as steel or aluminum; (b) forming the sheet into a cylindrical hoop or band; (c) securing the ends of the hoop together by a butt welding process; (d) flaring the lateral edges of the hoop radially outwardly to produce a rim preform having flanges suitable for positioning on a roll forming machine: (e) subjecting the rim preform to a series of roll forming operations to produce a wheel rim having a predetermined shape; and (f) expanding the wheel rim to produce a finished wheel rim having a predetermined circumference.

SUMMARY OF THE INVENTION

This invention relates to an improved wheel rim and method for producing the same. The wheel rim of the present invention is produced using a blank which has been formed into a hoop and having the opposed ends thereof joined together using a friction stir welding process. The method for producing the wheel rim of

the present invention includes the steps of: (a) providing a flat blank of material having a pair of opposed ends; (b) providing a chamfer in the opposed ends of the flat blank; (c) positioning the opposed ends of the blank adjacent one another to form a generally cylindrical hoop; (d) providing a pair of flats on the hoop in the region where the opposed ends meet; (e) joining the flattened opposed ends of the hoop together using a friction stir welding process; and (f) subjecting the hoop to one or more metal forming processes in order to produce a desired wheel rim. The use of the friction stir welding process to join the ends of the hoop together is more controllable, simpler, and uses less energy than the known butt welding process typically used to produce a prior art wheel rim.

Other advantages of this invention will become apparent to those skilled in the art from the following detailed description of the preferred embodiments, when read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating a first sequence of steps for producing a first embodiment of a wheel rim for use in a vehicle wheel in accordance with this invention.

Fig. 2 is a perspective view of a rim blank for use in producing the first embodiment of the wheel rim in accordance with the present invention.

Fig. 3 is a perspective view of the rim blank formed into a hoop for use in producing the first embodiment of the wheel rim in accordance with the present invention.

Fig. 3A is an enlarged sectional view of a portion of the hoop shown in Fig. 3.

Fig. 4 is a perspective view of a portion of the hoop which is welded together for use in producing the first embodiment of the wheel rim in accordance with the present invention.

Fig. 5 is a cross sectional view showing the expanding of the hoop in accordance with the present invention.

Fig. 6 is a cross sectional view showing the flaring of the hoop into a wheel rim preform in accordance with the present invention.

Fig. 7 is a cross sectional view showing the initial metal forming of the hoop into a partially formed wheel rim in accordance with the present invention.

Fig. 8 is a cross sectional view showing the intermediate metal forming of the partially formed wheel rim in accordance with this invention.

Fig. 9 is a cross sectional view showing the final metal forming of the partially formed wheel rim in accordance with this invention.

Fig. 10 is a cross sectional view showing the expanding of the wheel rim to produce the wheel rim in accordance with this invention.

Fig. 11 is a partial sectional view of a finished full face fabricated vehicle wheel constructed using the first embodiment of the wheel rim produced in accordance with this invention.

Fig. 12 is a block diagram illustrating a second sequence of steps for producing a second embodiment of a wheel rim for use in a vehicle wheel using a friction stir welding process in accordance with this invention.

Fig. 13 is a perspective view of a rim blank having chamfered ends for use in producing the second embodiment of the wheel rim in accordance with the present invention.

Fig. 14 is a perspective view of the rim blank having flattened end portions for use in producing the first embodiment of the wheel rim in accordance with the present invention.

Fig. 15 is a perspective view of the rim blank formed into a hoop for use in producing the second embodiment of the wheel rim in accordance with the present invention.

Fig. 16 is a perspective view of a portion of the hoop which is welded together for use in producing the second embodiment of the wheel rim in accordance with the present invention.

Fig. 17 is a partial sectional view of a finished ledge welded vehicle wheel constructed using the second embodiment of the wheel rim produced in accordance with this invention.

Fig. 18 is a partial cross sectional view of a finished well attached vehicle wheel constructed using a third alternate embodiment of a wheel rim produced in accordance with the present invention.

Fig. 19 is a partial cross sectional view of a finished bead seat attached vehicle wheel constructed using a fourth alternate embodiment of a wheel rim produced in accordance with the present invention.

Fig. 20 is a partial cross sectional view of a finished full face modular vehicle wheel constructed using a fifth alternate embodiment of a wheel rim produced in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings, there is illustrated in Fig. 1 a block diagram showing a first sequence of steps for producing a vehicle wheel 100, such as shown in Fig. 11, and which incorporates a first embodiment of a wheel rim, indicated generally at 58, constructed in accordance with this invention. As shown in this embodiment, the vehicle wheel 100 is a full face fabricated type of vehicle wheel which is typically found on a passenger car or light truck.

Initially in step 10, a flat sheet or blank 30 of suitable material, such as for example, steel, aluminum or alloys thereof, shown in Fig. 2 and having opposed ends 30A and 30B, is formed into a generally cylindrical hoop or band 32 shown in Fig. 3. Next, in step 12, the hoop 32 is welded using a friction stir welding process. To accomplish this, the hoop 32 is supported on a fixture (not shown) and a rotating tool 34 of a friction stir weld tool is used to form a weld 36 which is effective to secure the ends 30A and 30B of the hoop 32 together and thereby produce a welded hoop 38, partially shown in Fig. 4. Such a friction stir welding process is described in U.S. Patent No. 5,460,317 to Thomas et al., the disclosure of which is incorporated herein by reference. Preferably, in order to provide complete penetration of the friction stir weld 36, a groove or chamfer 30C and 30D is provided in a lower portion of the respective ends 30A and 30B of the flat sheet of material 30 so that when the ends 30A and 30B are placed adjacent one another, the chamfers 30C and 30D cooperate to form a generally inverted V-shaped annular groove 30E in the lower portion thereof, shown in Fig. 3A. Following this, the hoop 38 is expanded in step 14 to produce a substantially cylindrical hoop 40 shown in Fig. 5. In the illustrated embodiment, the hoop 40 extends a predetermined axial length X, includes an inner surface 40A which defines an inner diameter D1 and an outer surface 40B which defines an outer diameter D2, and includes a substantially uniform first thickness T throughout its entire axial length X. Alternatively, the hoop 40 can be other than illustrated if desired. For example, the hoop 40 can be of varying thicknesses as disclosed in U.S. Patent No. 5,832,609 to Jansen, the disclosure of which is incorporated herein by reference.

Next, in step 16, an end of the hoop 40 is flared upwardly as to produce a wheel rim preform 42 shown in Fig. 6. Following this, in steps 18, 20, and 22, the wheel rim preform 42 is subjected to a series of metal forming operations, as

shown in Figs. 7, 8, and 9, to progressively produce variable thickness wheel rims 44, 46, and 48, respectively. Preferably, the metal forming operations of steps 18, 20, and 22 include subjecting the wheel rim preform 42 to a series of roll forming operations since tighter tolerances can be maintained in the wheel rim 48. Alternatively, other metal forming operations can be used in one or more of the steps 18, 20, and 22 to progressively produce the wheel rim 48. For example, the wheel rim preform 42 can be subjected to forward or reverse flow spinning operations, pressing operations, or any suitable combinations of roll forming, flow spinning, and pressing operations which are operative to cause deformation, reshaping, and/or thinning of the metal to produce a variable thickness wheel rim having 48 having a desired profile. Also, as will be discussed below, the welded hoop 40 can be used to produce a generally uniform or constant thickness wheel rim, indicated generally at 158 in Fig. 17, which is illustrated as being joined to a wheel disc 170 to produce a vehicle wheel 200, which is illustrated as being a "ledge welded" vehicle wheel which is typically used on a medium or heavy duty truck.

As shown in Fig. 9, the wheel rim 48 includes an inboard tire bead seat retaining flange 50, an inboard tire bead seat 52, a generally axially extending well 54, and an outboard tire bead seat 56. Next, in step 24, the wheel rim 48 is expanded to produce a finished wheel rim 58. The finished wheel rim 58 defines a finished wheel rim axial length X1. In the illustrated embodiment, the axial length X1 of the finished wheel rim 58 is greater than the axial length X of the hoop 40. Alternatively, the axial length X of the hoop 40 and the axial length X1 of the finished wheel rim 58 can be other than illustrated. For example, depending upon the particular structures of the rim blank 30 and the wheel rim 58, the axial length X1 of the finished wheel rim 58 can be equal to or less than the axial length X of the hoop 40.

In step 26, the finished wheel rim 58 is secured to a preformed full face wheel disc 60 by a weld 80 to produce the finished full face fabricated vehicle wheel 100, shown in Fig. 11. As shown therein, the wheel disc 60 includes a central mounting portion 62, an intermediate bowl-shaped portion 64, and an outer annular portion 66 which defines an outboard tire bead seat retaining flange 68 of the full face fabricated vehicle wheel 100. The wheel disc 60 can be formed from a suitable material, such as for example, steel, aluminum or alloys thereof.

Referring now to Fig. 12, there is illustrated a block diagram showing a second sequence of steps for producing a vehicle wheel 200, such as shown in Fig. 17, and which incorporates a second embodiment of a wheel rim, indicated generally at 158, constructed in accordance with this invention. As shown in this embodiment, the vehicle wheel 200 is a fabricated truck type of vehicle wheel. Initially in step 110, opposed ends 132 and 134 of a flat sheet or blank 130 of suitable material, such as for example, steel, aluminum or alloys thereof, are provided with chamfers 132A and 134A, respectively, as shown in Fig. 13. Next, in step 112, the opposed ends 132 and 134 are provided with "flattened" portions 136 and 138, respectively, shown in Fig. 14. As used herein, the term flattened portion means a portion of the blank 130 which is oriented at a predetermined angle relative to the remainder of the generally planar surface of the blank 130.

In step 114, the opposed ends 132 and 134 are positioned adjacent one another so as to form the blank 130 into a generally cylindrical hoop or band 142 shown in Fig. 15. Next, in step 116, the hoop 142 is welded using a friction stir welding process. To accomplish this, the hoop 142 is supported on a fixture (not shown) and a rotating tool 144 of a friction stir weld tool is used to form a weld 146 which is effective to secure the ends 132 and 134 of the hoop 142 together and thereby produce a welded hoop 148, partially shown in Fig. 16. As shown in Fig. 16, the chamfered ends 132A and 134A cooperate to define a generally

inverted V-shaped opening or recess in lower portion of the hoop 142 which is effective to provide complete penetration of the friction stir weld 146. Also, as shown in Fig. 16, the flattened portions 136 and 138 of the hoop 142 extend a predetermined distance X2 and X3, respectively, relative to ends 132 and 134 thereof. In the illustrated embodiment, the distance X2 and X3 are generally equal to one another. However, the distances X2 and X3 can be other than illustrated if desired.

Following this, the hoop 142 is expanded in step 118, flared in step 120, subjected to a series of metal forming operations in steps 122, 124, and 126, and expanded in step 128 to produce the generally constant thickness truck style wheel rim 158, shown in Fig. 17. Next, in step 130, the finished wheel rim 158 is secured to a preformed wheel disc 170 by a weld 180 to produce the finished ledge welded truck style vehicle wheel 200, shown in Fig. 17. As shown therein, the wheel rim 158 includes an inboard tire bead seat retaining flange 160, an inboard tire bead seat 162, a well 164, an outboard tire bead seat 166, and an outboard tire bead seat retaining flange 168. The wheel disc 170 includes a central mounting portion 172 and an outer annular portion 174. The wheel disc 170 can be formed from a suitable material, such as for example, steel, aluminum or alloys thereof.

While the present invention has been illustrated and described as forming a variable thickness wheel rim 58 for use in a full face fabricated vehicle wheel 100, and a constant thickness wheel rim 158 for use in a ledge welded vehicle wheel 200, the present invention can be practiced to form an associated wheel rim for use in other types of wheels. For example, as shown in Fig. 18, the present invention can be practiced to produce a wheel rim 210, which is secured to a preformed wheel disc 212 to produce a well-attached fabricated vehicle wheel 214. Also, as shown in Fig. 19, the present invention can be practiced to produce

a wheel rim 220, which is secured to a preformed wheel disc 224 to produce a bead seat attached fabricated vehicle wheel 224. In addition, as shown in Fig. 20, the present invention can be practiced to produce a partial wheel rim 230, which is secured to a cast full face wheel disc 232 to produce a full face modular vehicle wheel 234.

One advantage of the present invention is that the friction stir welding process is more controllable than the prior art current butt welding process that is used to form the prior art welded hoop. Also, using the friction stir welding to weld the ends of the hoop together in accordance with the present invention is simpler and uses less energy than the known prior art butt welding process typically used to weld the ends together of the prior art welded hoop used in making the prior art wheel rim.

In accordance with the provisions of the patents statues, the principle and mode of operation of this invention have been described and illustrated in its preferred embodiments. However, it must be understood that the invention may be practiced otherwise than as specifically explained and illustrated without departing from the scope or spirit of the attached claims.

WHAT IS CLAIMED IS:

1. A method for forming a hoop comprising the steps of:

(a) providing a flat blank of material having a pair of opposed ends;

(b) positioning the opposed ends of the flat blank adjacent one another to form a generally cylindrical hoop; and

(c) joining the flattened opposed ends of the hoop together by a friction stir welding process.

2. The method according to Claim 1 and prior to step (c) the step of forming a pair of flats on the hoop in the region where the opposed ends meet.

3. The method according to Claim 1 and prior to step (c) the step providing a chamfer in the opposed ends of the flat blank, the chamfer in the opposed ends of the flat blank cooperates to define a generally inverted V-shaped opening in the hoop.

4. The method according to Claim 1 and subsequent to step (c) the step of subjecting the hoop to one or more metal forming processes in order to produce a wheel rim having a desired shape.

5. The method according to Claim 4 wherein the hoop is subjected to a series of roll forming operations.

6. The method according to Claim 4 wherein the hoop is subjected to a series of flow spinning operations.

7. The method according to Claim 4 wherein the hoop is subjected to a series of flow spinning and roll forming operations.

8. The method according to Claim 4 wherein the metal forming processes are operative to produce a wheel rim having a generally uniform thickness.

9. The method according to Clam 4 wherein the wheel rim includes at least an inboard tire bead seat retaining flange, an inboard tire bead seat, a well, and an outboard tire bead seat.

10. A method for forming a wheel rim comprising the steps of:

(a) providing a flat blank of material having a pair of opposed ends;

(b) forming a chamfer in the opposed ends of the flat blank;

(c) positioning the opposed ends of the blank adjacent one another to form a generally cylindrical hoop;

(d) forming a pair of flats on the hoop in the region where the opposed ends meet;

(e) joining the flattened opposed ends of the hoop together using a friction stir welding process; and

(f) subjecting the hoop to one or more metal forming processes in order to produce a desired wheel rim.

11. The method according to Claim 10 wherein the flat on one end of the hoop extends a first predetermined distance and the flat on an opposite end of the hoop extends a second predetermined distance which is generally the same as the first predetermined distance.

12. The method according to Claim 10 wherein the metal forming processes of step (f) are operative to produce a generally uniform thickness wheel rim.

13. The method according to Claim 10 wherein during step (f) the hoop is subjected to a series of roll forming operations.

14. The method according to Claim 10 wherein during step (f) the hoop is subjected to a series of flow spinning operations.

15. The method according to Claim 10 wherein during step (f) the hoop is subjected to a series of flow spinning and roll forming operations.

16. The method according to Claim 10 wherein during step (f) the metal forming processes are operative to produce a wheel rim having a generally uniform thickness.

17. The method according to Claim 10 wherein the wheel rim includes at least an inboard tire bead seat retaining flange, an inboard tire bead seat, a well, and an outboard tire bead seat.

18. The method according to Claim 10 and further including the step of securing the wheel rim to a preformed wheel disc to produce a vehicle wheel.

19. A hoop adapted for use in producing a wheel rim for use in a vehicle wheel comprising:

a generally cylindrical hoop formed from a generally flat blank having opposed ends thereof joined together by a friction stir welding process.

20. The hoop defined in Claim 19 wherein said hoop includes a pair of flats formed therein in a region wherein said opposed ends meet

21. The hoop defined in Claim 19 wherein said hoop includes a chamfer in said opposed ends, said chamfer in said opposed ends adapted to define a generally inverted V-shaped opening in a lower portion of said hoop which is effective to provide complete penetration of the weld.

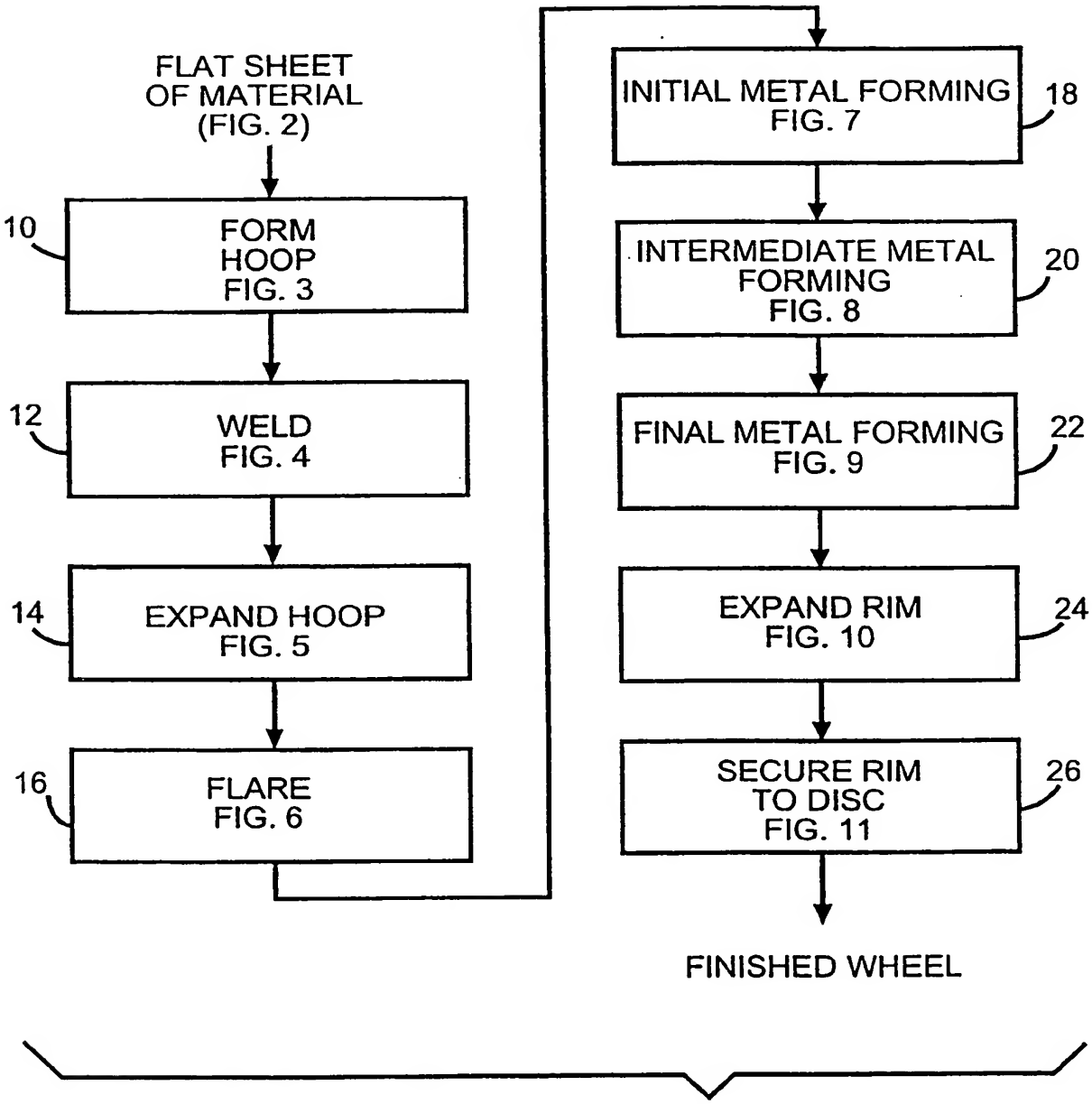
FLAT SHEET OF MATERIAL (FIG. 2)
10
FORM HOOP FIG. 3
12
WELD FIG. 4
14
EXPAND HOOP FIG. 5
16
FLARE FIG. 6
INITIAL METAL FORMING FIG. 7
18
INTERMEDIATE METAL FORMING FIG. 8
20
FINAL METAL FORMING FIG. 9
22
EXPAND RIM FIG. 10
24
SECURE RIM TO DISC FIG. 11
26
FINISHED WHEEL

FIG. 1

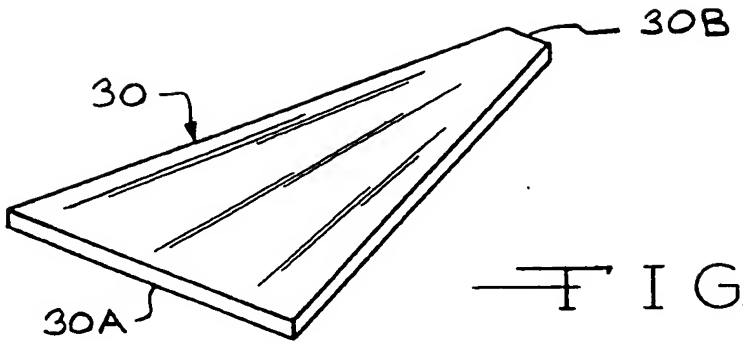

FIG. 2

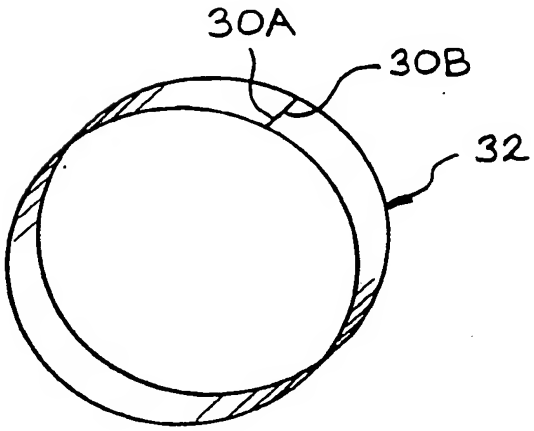

FIG. 3

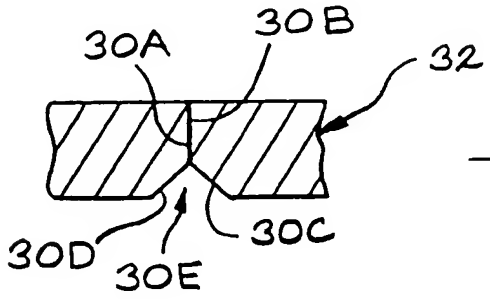

FIG. 3A

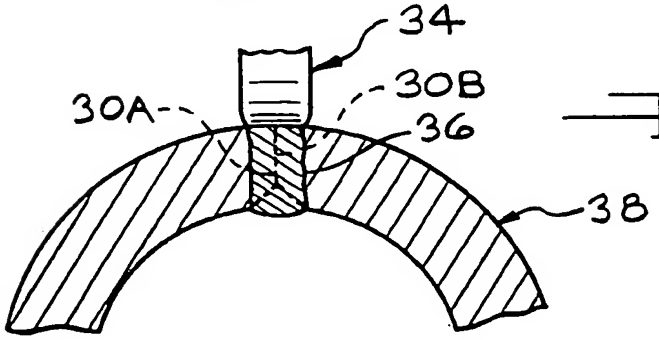

FIG. 4

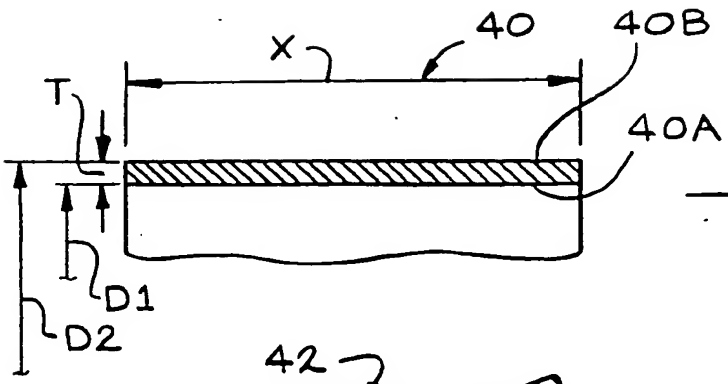

FIG. 5

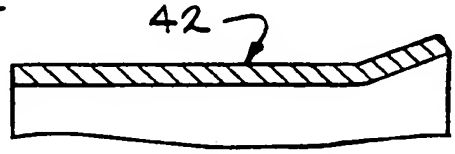

FIG. 6

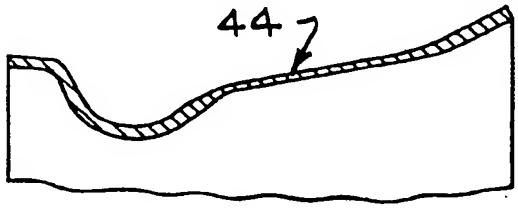

FIG. 7

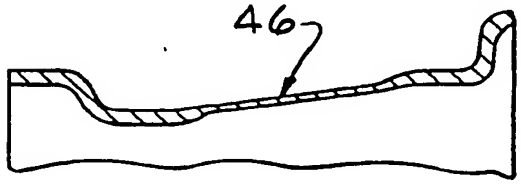

FIG. 8

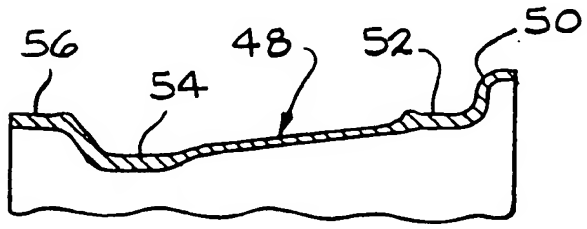

FIG. 9

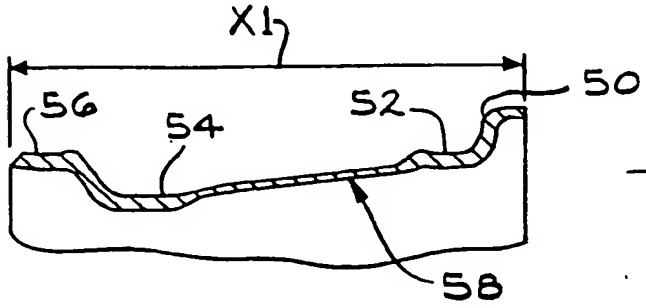

FIG. 10

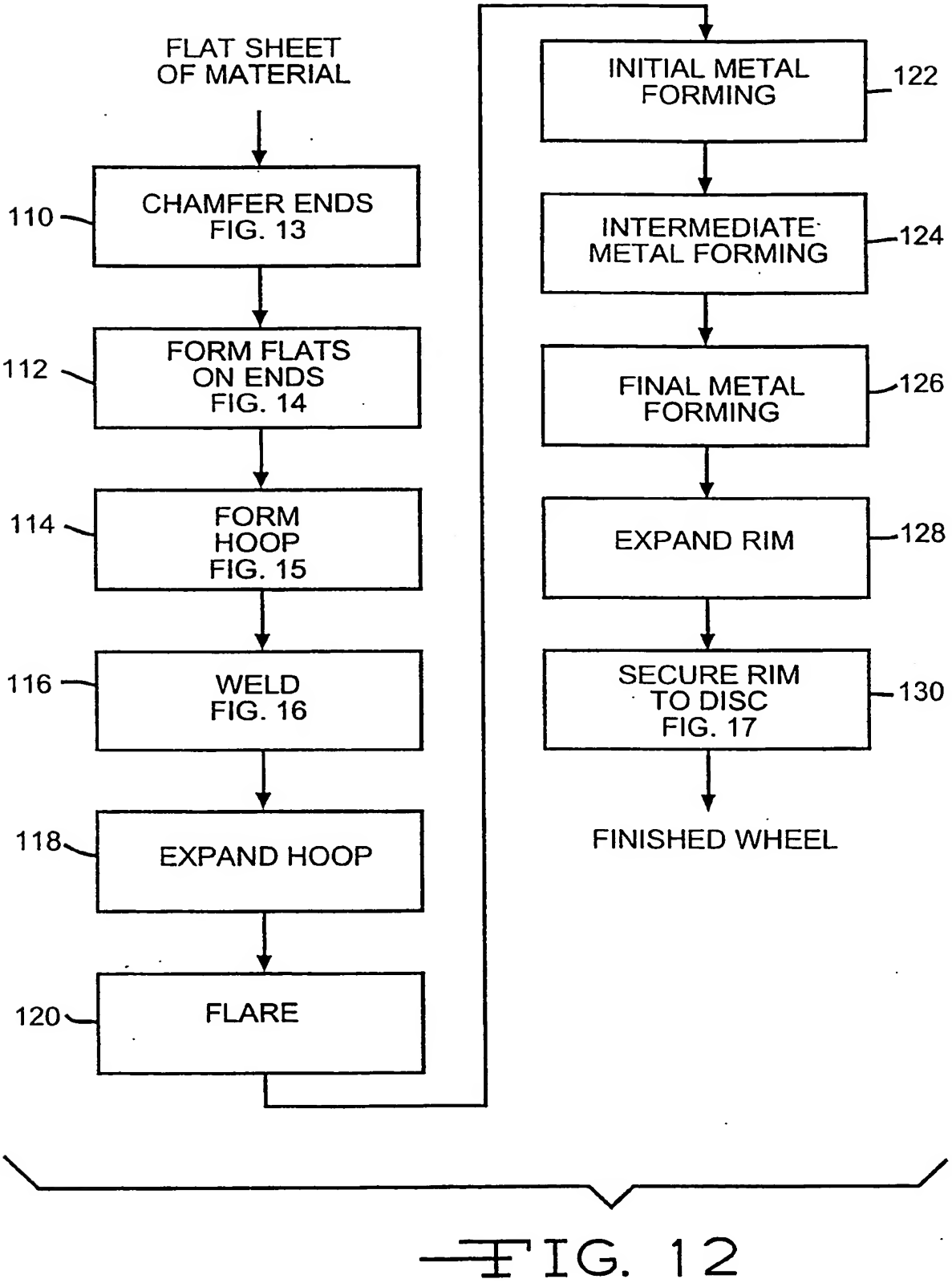
FLAT SHEET OF MATERIAL
110
CHAMFER ENDS FIG. 13
112
FORM FLATS ON ENDS FIG. 14
114
FORM HOOP FIG. 15
116
WELD FIG. 16
118
EXPAND HOOP
120
FLARE
122
INITIAL METAL FORMING
124
INTERMEDIATE METAL FORMING
126
FINAL METAL FORMING
128
EXPAND RIM
130
SECURE RIM TO DISC FIG. 17
FINISHED WHEEL

FIG. 12

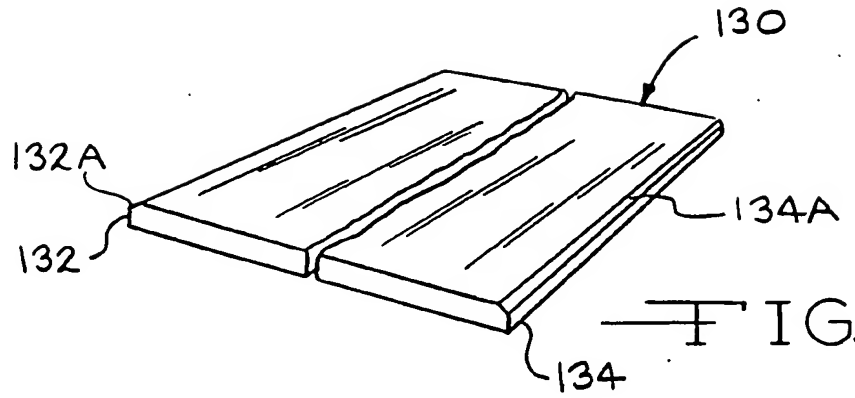

FIG. 13

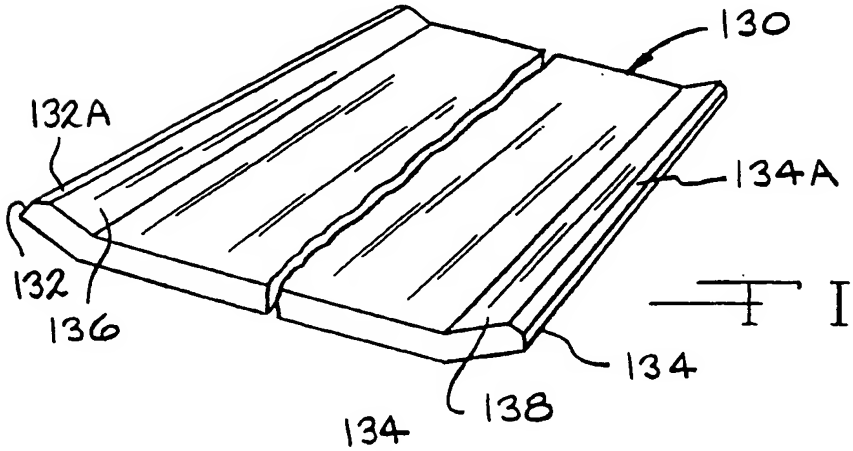

FIG. 14

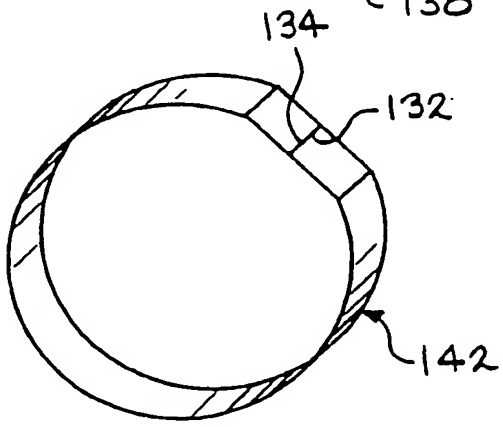

FIG. 15

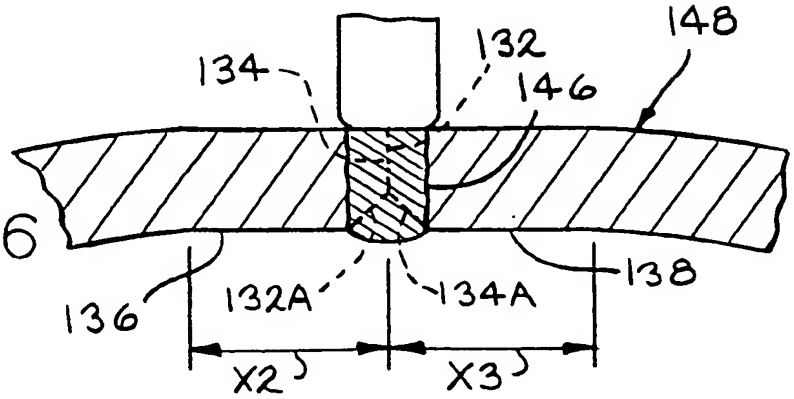

FIG. 16

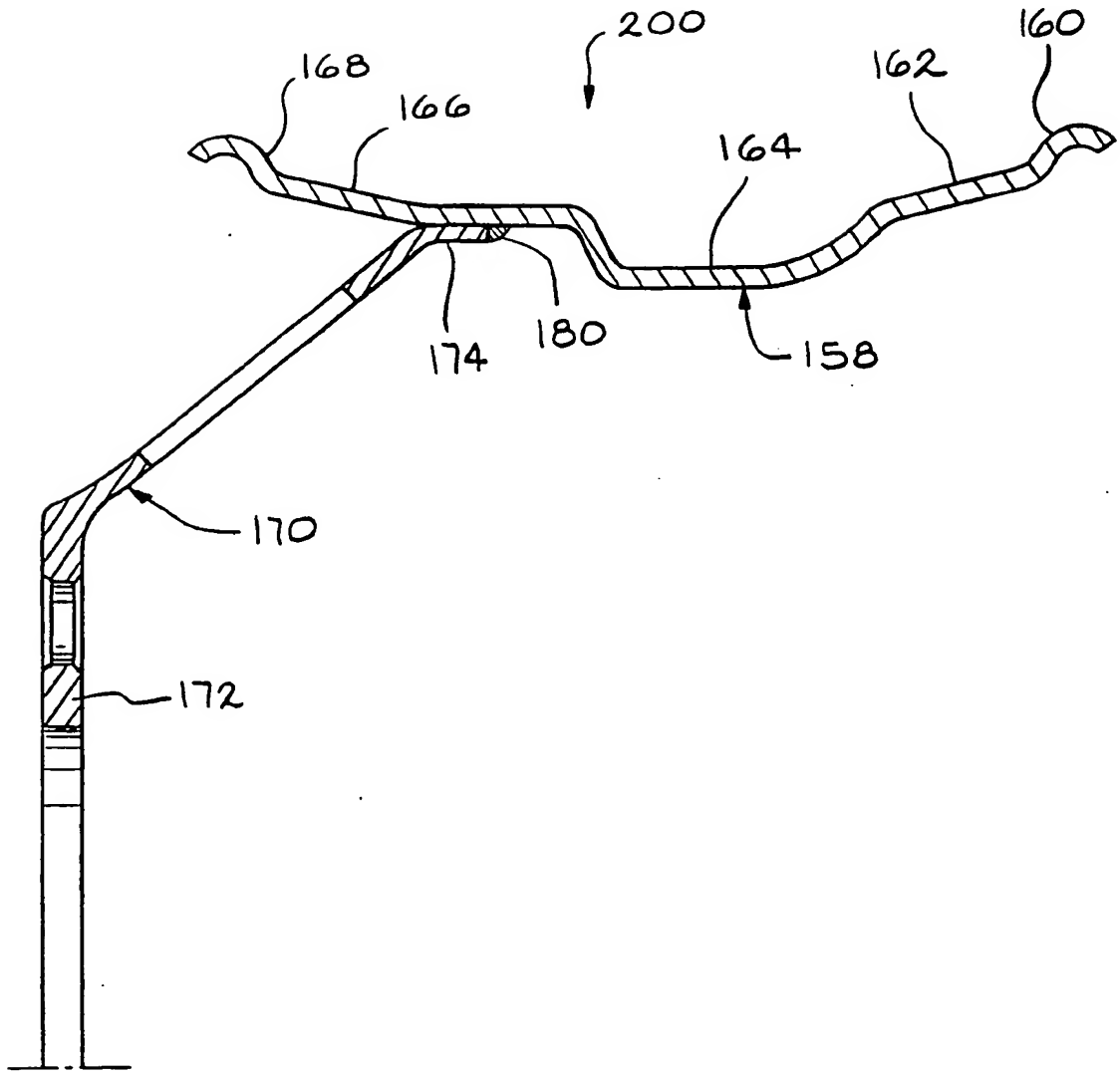

FIG. 17

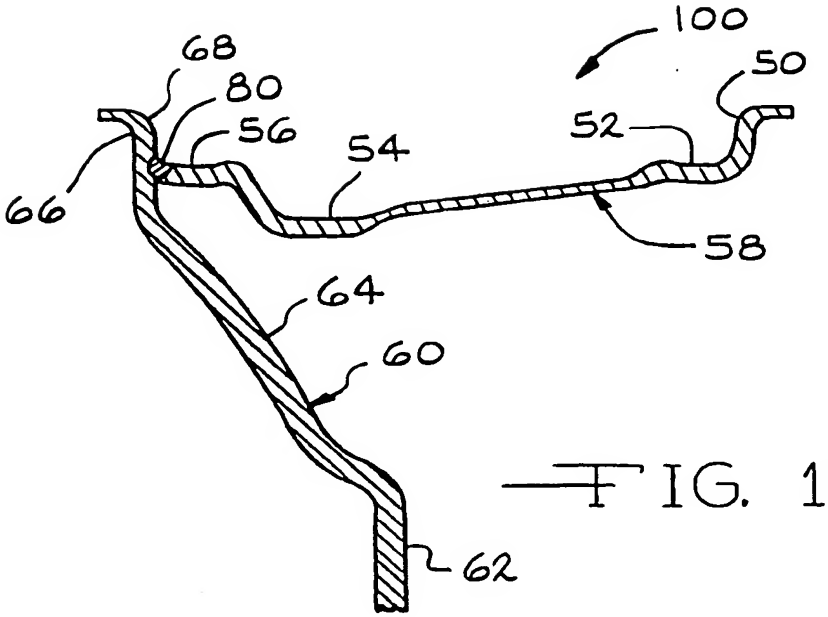

FIG. 11

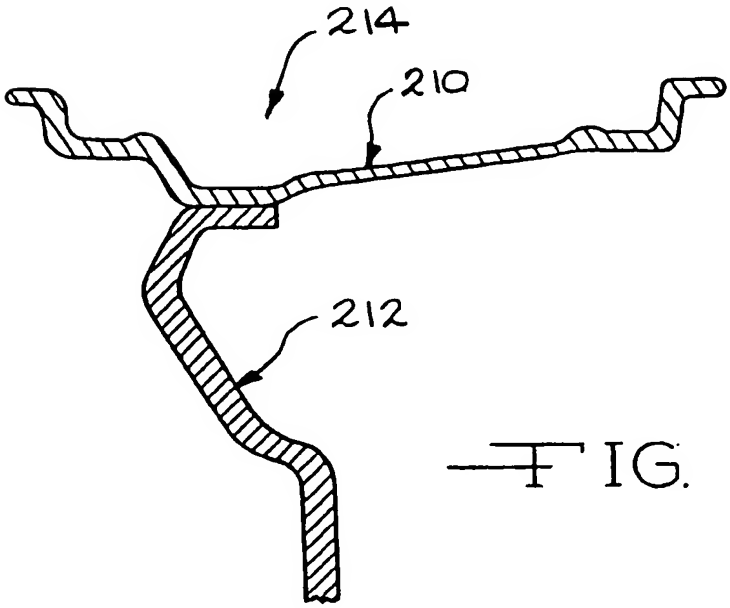

FIG. 18

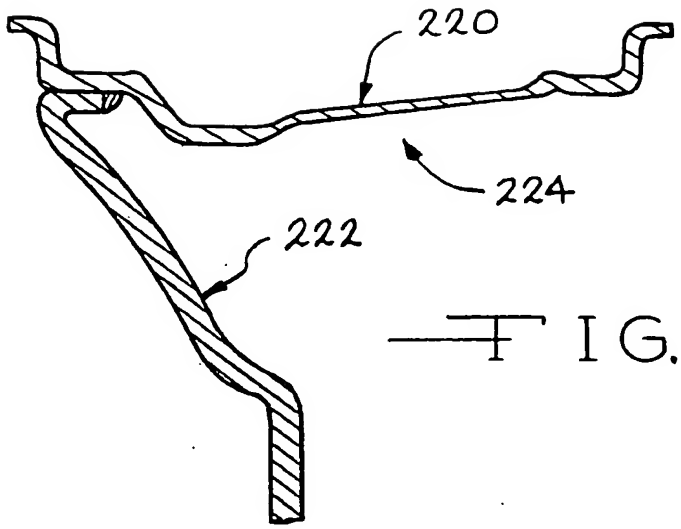

FIG. 19

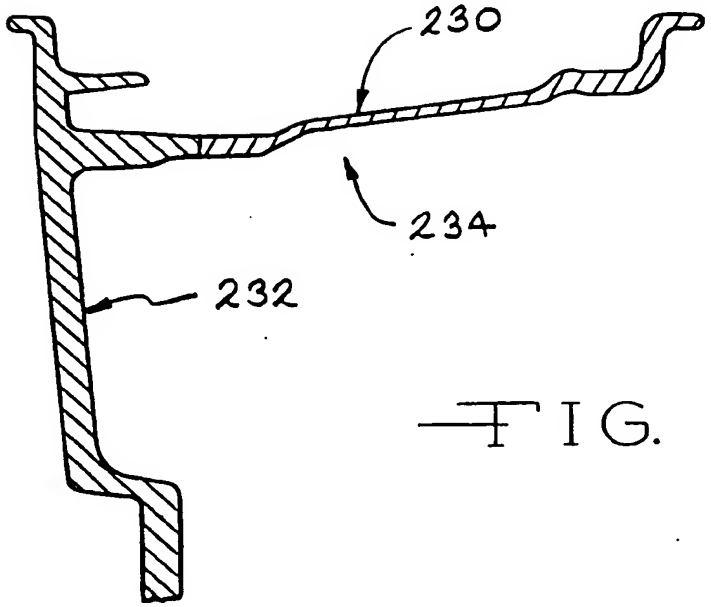

FIG. 20

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/27853

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B21D53/30 B23K20/12 B60B5/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B21D B23K B60B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DAWES C J ET AL: "FRICTION STIR PROCESS WELDS ALUMINUM ALLOYS" WELDING JOURNAL INCLUDING: WELDING RESEARCH, vol. 75, no. 3, 1 March 1996, pages 41-45, XP000587301	1,19
A	see table 2	10
A	US 5 682 677 A (MAHONEY MURRAY) 4 November 1997 see the whole document	1,4,5,8, 9
A	US 4 185 370 A (EVANS JAMES L) 29 January 1980 cited in the application see the whole document	1,4-10, 12-19

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 April 1999	03/05/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ris, M

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 98/27853

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 611 479 A (ROSEN CHARLES D) 18 March 1997 see the whole document	3,21

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 98/27853

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5682677 A	04-11-1997	AU 3828297 A WO 9806532 A	06-03-1998 19-02-1998
US 4185370 A	29-01-1980	NONE	
US 5611479 A	18-03-1997	NONE	